

During the public comment period several commenters requested specific allocation options and stream conditions be considered by the Environmental Protection Agency (EPA). In response to those comments, EPA has applied the model under varying conditions and considerations. This Appendix presents the results of the additional analysis based on comments received. All of the comparison runs shown in this Appendix are based on meeting the state water quality standard for trout stocking fishes of 5 mg/L daily minimum and 6 mg/L daily average.

I. Impacts of Varying Flows from Loraine Run and Coorson's Quarry

Loraine Run receives flow from Coorson's Quarry. The present National Pollutant Discharge Elimination System (NPDES) permit for the quarry provides for a maximum flow and a minimum flow, 8 CFS and 0.5 CFS respectively. The allocation runs for the Wissahickon Creek watershed were based on the higher flow of 8 CFS coming from the quarry. There were concerns from a few of the commenters that a reduced flow from Coorson's Quarry would adversely impact the assimilative capacity of the Wissahickon Creek and therefore the Wissahickon Creek would not meet the dissolved oxygen standards based on the allowable loads from this TMDL. In order to determine if a reduced flow, one that would equal the lower flow allowed by the existing NPDES permit, would have an impact on the allocations assigned to the five significant point sources, EPA determined, using the water quality model, the allocations to the point sources necessary to meet water quality standards if the flow from the quarry were 0.5 CFS, the minimum allowed by the NPDES permit. Lorraine Run discharges to the Wissahickon Creek below the area of projected minimum dissolved oxygen at the TMDL design conditions and therefore has little or no impact on the allowable waste load allocations. The table below provides the comparison of the allocations under the two quarry flows.

Table D.1 - Impact of Varying Flow from Coorson's Quarry

WWTP ->	<i>North Wales</i>		<i>Upper Gwynedd</i>		<i>Ambler</i>		<i>Abington</i>		<i>Upper Dublin</i>	
Quarry -> flow	8 CFS	0.5 CFS	8 CFS	0.5 CFS	8 CFS	0.5 CFS	8 CFS	0.5 CFS	8 CFS	0.5 CFS
DO (mg/L)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
CBOD5 (mg/L)	3.00	3.00	5.00	5.00	10.00	10.00	7.50	7.50	12.75	12.75
NH3-N (mg/L)	0.50	0.50	0.74	0.74	1.50	1.50	0.72	0.72	2.25	2.25
NO3+NO2-N (mg/L)	15.15	15.15	17.64	17.64	36.40	36.40	25.92	25.92	38.57	38.57
ortho PO4-P (mg/L)	1.41	1.41	1.59	1.59	4.53	4.53	1.53	1.53	1.85	1.85

II. Impacts of Varying Effluent Dissolved Oxygen Concentrations

Existing permitted effluent minimum dissolved oxygen values range from 5 mg/l to 6 mg/l depending on the facility. The allocations presented in this TMDL report are based on an effluent dissolved oxygen minimum daily concentration of 7 mg/l. This concentration was chosen for the allocation runs based on numerous discussions with representatives of several of the municipal facilities.

In order to determine the impact of varying effluent dissolved oxygen concentrations, EPA performed modeling analysis assuming effluent dissolved oxygen concentrations from the five point sources of 6 mg/l, 7.5 mg/l, 7.75 mg/l and 8.0 mg/l. The following tables present the results of those analysis. It can be seen that as the effluent dissolved oxygen concentrations increase the allowable concentrations of the pollutants also increase slightly.

Table D-2 - Allocations at Effluent DO of 6.0 mg/L

	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin
DO (mg/L)	6.0	6.0	6.0	6.0	6.0
CBOD5 (mg/L)	0.50	2.00	10.00	2.80	5.25
NH3-N (mg/L)	0.13	0.45	1.50	0.52	1.25
NO3+NO2-N (mg/L)	15.15	20.08	30.50	30.27	36.71
ortho PO4-P (mg/L)	0.47	1.11	4.68	1.39	1.64

Table D-3 - Allocations at Effluent DO of 7.0 mg/L

	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin
DO (mg/L)	7.0	7.0	7.0	7.0	7.0
CBOD5 (mg/L)	3.00	5.00	10.00	7.50	12.75
NH3-N (mg/L)	0.50	0.74	1.50	0.72	2.25
NO3+NO2-N (mg/L)	15.15	17.64	36.40	25.92	38.57
ortho PO4-P (mg/L)	1.41	1.59	4.53	1.53	1.85

Table D-4 - Allocations at Effluent DO of 7.5 mg/L

	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin
DO (mg/L)	7.5	7.5	7.5	7.5	7.5
CBOD5 (mg/L)	3.60	5.40	10.00	8.20	13.50
NH3-N (mg/L)	0.60	0.74	1.50	1.32	2.30
NO3+NO2-N (mg/L)	21.21	19.06	30.30	30.27	32.84
ortho PO4-P (mg/L)	1.55	1.71	4.68	2.92	1.96

Table D-5 - Allocations at Effluent DO of 7.75 mg/L

	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin
DO (mg/L)	7.75	7.75	7.75	7.75	7.75
CBOD5 (mg/L)	3.90	5.50	10.00	8.30	13.65
NH3-N (mg/L)	0.65	0.77	1.50	1.32	2.30
NO3+NO2-N (mg/L)	21.21	19.06	30.30	30.27	32.84
ortho PO4-P (mg/L)	1.64	1.75	4.68	2.92	1.96

Table D-6 - Allocations at Effluent DO of 8.0 mg/L

	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin
DO (mg/L)	8.0	8.0	8.0	8.0	8.0
CBOD5 (mg/L)	4.10	5.70	10.00	8.70	13.80
NH3-N (mg/L)	0.73	0.81	1.50	1.40	2.33
NO3+NO2-N (mg/L)	21.21	19.06	30.30	30.27	32.84
ortho PO4-P (mg/L)	1.74	1.79	4.68	3.15	1.98

III. Projected Impairments at Existing Permitted Flows and Concentrations

The water quality model was used to project the impairment in the Wissahickon Creek watershed when the five municipal facilities are built out and discharging at the levels that they are permitted to discharge. The model was used to determine the areas of the creek that will not meet the state water quality criteria for dissolved oxygen (for a trout stocking use) of 5 mg/l daily minimum and 6 mg/l daily average. Table D-7 shows the effluent concentrations that were used for this analysis. The effluent flows are those that are allowed by the existing permit, the CBOD5, ammonia and effluent dissolved oxygen concentrations are those in required by the existing permit and, since nitrite-nitrate and phosphorus are not now permit limitations, the concentrations used are based on data collected by the facilities in 2002. The Table also shows the impact on the creek's dissolved oxygen, shown as percent of stream miles not meeting the state water quality standards. Figure D-1 shows the stream locations where the dissolved oxygen standard would not be met.

Table D-7 - Stream Miles Impaired at Permit Conditions

	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin	% Impaired for DO	
						Min DO of 5 mg/L	Ave DO of 6 mg/L
DO (mg/L)	6.0	6.0	6.0	6.0	6.0	45 percent of the stream miles in the Wissahickon Creek impaired	53 percent of the stream miles in the Wissahickon Creek Impaired
CBOD5 (mg/L)	10.00	10.00	10.00	10.00	15.00		
NH3-N (mg/L)	2.50	1.80	1.50	2.00	2.50		
NO3+NO2-N (mg/L)	15.15	12.60	18.20	21.60	20.30		
ortho PO4-P (mg/L)	4.69	3.12	4.53	3.82	2.94		

Figure D-1: Locations of Stream Standards Violations under Existing Permitted Conditions

IV. Control of Phosphorus to Reduce Nuisance Algal Growth

There was interest by Pennsylvania Department of Environmental Protection (DEP) to evaluate the impacts reducing phosphorus on not only the allocations for the other pollutants based on a dissolved oxygen standard but also on the in stream phosphorus concentration. The focus of this TMDL has been on the protection of aquatic life by assuring that the state's water quality standard for dissolved oxygen is met. However, DEP has also indicated that control of nutrients may also be necessary to address other potential uses by humans by reducing nuisance algal growths. Control of nuisance algal growth may require in stream concentrations of phosphorus below that which is necessary in order to meet the dissolved oxygen standards. EPA agrees that the control of nutrients to assure that the dissolved oxygen concentration in the receiving waters may not be sufficient to adequately control algae at below nuisance levels. Because this TMDL has focused on the need to protect the dissolved oxygen levels in the Wissahickon and its tributaries, no site-specific data was collected to determine the levels of phosphorus in stream that would be necessary to control the growth of algae beyond the dissolved oxygen consideration. In addition, no target concentrations of phosphorus are available to EPA to include these considerations in the determination of this TMDL.

The determination of target phosphorus in stream concentrations for the purpose of establishing a TMDL solely for algae control is difficult. Researchers involved in other TMDL studies¹ have estimated that in-stream concentrations of soluble phosphorus could range from as low as 1 to 4 ug/L (Spokane River) to above 100 ug/l (Tualatin River). For the Tualatin River, researchers found that a noticeable reduction in algal growth occurred at 100 ug/L phosphorus and at approximately 50 ug/L phosphorus, low growth conditions prevailed. These numbers do not represent instantaneous or daily maximums and are not comparable to those in-stream concentrations reported in the TMDL. In-stream concentrations contained in the TMDL correspond to a "worst case" scenario (i.e. extreme low flows) and are artificially inflated in relation to the in-stream concentrations in the studies cited above. The phosphorus target developed for the Tualatin River study, for example, was to be applied as a monthly mean from May 1 to October 1 and takes into account the full spectrum of flow regimes over that period. Therefore, periods of high flows and dilution are included in the Tualatin River study, whereas, the TMDL in-stream concentration is for a point in time where dilution is almost non-existent. Because in-stream phosphorus targets are not set under conditions consistent with TMDL design conditions, literature in-stream phosphorus numbers purported to limit algal growth are of no use for TMDL comparisons. Phosphorus indicators (TMDL endpoints) are not easy to implement in rivers and streams, particularly in fast-flowing, gravel or cobble bed streams which are impaired more by attached algae than free-floating algae, as is the case in the Wissahickon Creek. The

¹ "Protocol for Developing Nutrient TMDLs - First Edition", EPA 841-B-89-007, November 1999.

relationship between phosphorus concentration and plant growth is not as well established in these systems.

EPA believes that the TMDL presented in this report is sufficient to attain and maintain the dissolved oxygen standards for the Wissahickon Creek and its tributaries under the critical low flow design conditions. However, following implementation of this TMDL and evaluation of stream conditions, additional nutrient removal by the significant sources may be necessary in order to reduce the algal growth in the stream to below nuisance levels. There are options available in order to address this issue if necessary. Phosphorus indicators (TMDL endpoints) are not easy to implement in rivers and streams, particularly in fast-flowing, gravel or cobble bed streams which are impaired more by attached algae than free-floating algae, as is the case in the Wissahickon Creek. The relationship between phosphorus concentration and plant growth is not as well established in these systems. One option would be to determine the end point (the level of algal growth that would be below the nuisance level threshold) that would adequately interpret the state's narrative water quality standard and then conduct appropriate studies to determine the in stream levels of phosphorus necessary to maintain that interpretation level. For instance, the state could choose chlorophyll "a", periphyton biomass or transparency as end points. As an example, if a chlorophyll "a" concentration is selected as the applicable end point, then algal growth studies could be conducted to determine the concentrations of phosphorus that would achieve the given end point.

Another option would be to determine the end point visually. With this approach, the treatment facilities would construct and meet the load requirements of the dissolved oxygen TMDL. Following this, observations would be made during the appropriate season to determine if algae is still present at undesirable levels. If these observations showed that algal growth is still an issue, then the significant sources of phosphorus would be required to further reduce the loading of phosphorus to the stream. This process could be repeated, as necessary.

As an example, the dissolved oxygen TMDL requires effluent phosphorus concentrations of from 1.4 mg/L to 4.68 mg/L for the five significant point sources. Each facility could be required to meet these phosphorus concentrations within a given time period, after which stream observations would be made. In this example, if the observations show that algal growth is still significant, additional nutrients must be removed from the system. The point sources could be required to remove phosphorus down to a lower level, for example, 1 mg/L. This iterative process could continue reducing the phosphorus levels in the effluent until the algal growth has been reduced to acceptable levels.

A third option would be to build to meet the phosphorus requirements of the dissolved oxygen TMDL. The second stage of nutrient control would then occur after the state has adopted nutrient water quality standards, which is scheduled for 2007. At that time no interpretation of the state's water quality standard would be necessary.

Appendix D

A fourth option to consider is the application of technology limits and water quality-based limits based on the TMDL, for phosphorus for all five of the significant point sources. According to PADEP guidance “Final Implementation Guidance for Section 95.9 Phosphorus Discharges to Free Flowing Streams” (document number 391-2000-018), 1997, technology-based limits for phosphorus will be imposed where excessive nutrients are suspected to be a problem. Other approaches could be used at a later time to determine if further controls are necessary to reduce the algal growth to below nuisance levels.

Although EPA firmly stands behind the TMDL load reductions necessary to attain and maintain the dissolved oxygen water quality standards, EPA also believes that further study is needed on the Wissahickon Creek to better determine the phosphorus reductions necessary to control nuisance algal growth. Since no algal growth studies have been performed on the Wissahickon Creek, as noted above, the determination of the phosphorus concentration that would create a low, non-nuisance growth condition is not known.

Regionalized Treatment

The TMDL did not consider the possibility of regionalization, or combining several municipals’ wastewater for treatment at one common facility. Because of the distances between facilities, it did not appear to be a likely alternative. However, there was a request to combine the flows of North Wales and Upper Gwynedd Township at the Upper Gwynedd facility. Table D-9 below shows the allocations associated with this combined treatment at Upper Gwynedd.

Table D-9: Allocations with Flows for North Wales Directed to Upper Gwynedd

WWTP	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin
CBOD5 (mg/L)	NA	4.40	10.00	7.50	12.75
NH3-N (mg/L)	NA	0.65	1.50	0.72	2.25
NO3-NO2 (mg/L)	NA	19.93	29.90	30.27	36.71
ORTHO-PO4	NA	1.61	4.68	1.85	1.45

V. Effluent Flows During Design Low Flow Conditions

Several commenters were concerned that the allocation process used permitted design flows. It was argued that the design flows would never be met during dry weather conditions and that a lesser flow should be used as representative of dry conditions. It was believed that EPA’s assumption that maximum flows at all facilities would occur at the same time during dry weather was a very conservative approach. EPA used PADEP’s guidance, “Chapter 3 -

Development of Water Quality Based Effluent Limitations, October 1997) as the basis for use of the design effluent flow. This guidance states that “For sewage discharges, Q_w should be the design flow for the treatment facilities...”. EPA evaluated this concern by obtaining effluent flows for several facilities during the extreme dry weather conditions during the summer of 2002, determining ratios of those dry weather flows with reported wet weather flows and used those ratios to adjust the design flows for the allocation process. For facilities where flows could not be obtained, similar ratios were used as were calculated for those facilities where flow data was readily available. Table D-10 shows the ratios used for each facility. Table D-11 shows the allocations resulting from this reduced dry weather flow.

As can be seen from Table D-11, the allocations are more stringent at these reduced effluent flows. These reduced loadings are required because when the discharger flows are reduced the water depth in the upper reaches become less resulting in reduced reareation and greater algal impacts. Because the effluent flows are a major part of the entire stream flows, any changes in the effluent flow and quality will have a significant impact on in stream conditions.

Table D-10: Design Flow Dry Weather Flow Ratios

	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin
Design Flow (MGD)	0.835	5.7	6.5	3.91	1.1
Dry Flow (MGD)	0.638	4.2	4.3	3.52	0.8
Ratio	0.764	0.732	0.660	0.900	0.764

Table D-11: Allocations with Reduced Flows at Dry Weather

	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin
CBOD (mg/L)	2.0	3.9	10.0	6.5	11.7
NH3 (mg/L)	0.5	0.63	1.5	0.74	2.25
NO3-NO2 (mg/L)	15.15	20.66	33.94	36.32	36.71
Ortho - PO4 (mg/L)	1.41	1.82	24.68	1.85	1.45

VI. Consideration of Seasonal Stream Flows

As a result of public concerns raised in comments to the draft TMDL report for Wissahickon Creek, EPA performed a sensitivity analysis to assess the impacts to the waste load allocations with 7 day 10 year low flows (7Q10) flows calculated specifically for each season of the TMDL. The following were the 7Q10 flows calculated at the mouth of Wissahickon Creek (USGS gage 01474000) for the two seasons considered by the TMDL:

Trout Stocking (June-July):20.83 cfs
Warm Water Fishes (Aug-Sept)17.77 cfs

Both these 7Q10 flows are greater than the 16.3 cfs (based on all historical data at United States Geological Survey (USGS) gage 01474000) used in TMDL analysis. Although the critical flow for TMDL analysis was based on the 7Q10, adjustments were necessary to account for special considerations for the Wissahickon Creek. As discussed in the *Modeling Report for Wissahickon Creek, Pennsylvania, Nutrient TMDL Development* (hereafter referred to as Modeling Report), the flow budget for Wissahickon Creek critical flow had to account for special circumstances including:

- Combined STP design flows (27.96) exceeded the 7Q10
- Average discharge from Coorson's Quarry of 12.5 cfs
- Too low flow in headwaters resulted in model instability

As a result of these limitations, a special methodology was required for configuration of critical low-flow conditions. This methodology was reported in the Modeling Report. The resulting critical flow included:

- 7Q10 baseflow (without point source contributions)
- All STP design flows as allowed in their respective NPDES permits and required by the TMDL to ensure protection of the stream under the most critical conditions
- Average discharge from Coorson's Quarry of 12.5 cfs
- Minimum flows at headwaters to prevent model instability

The resulting critical flow for TMDL analysis was 42.52 cfs at the mouth of Wissahickon Creek. Calculation of the 7Q10 baseflow (1.4 cfs) was based on average STP discharge flows of summer 2002. Performing a similar calculation using the Trout Stocking and Warm Water Fishes seasonal 7Q10 flows results in a background flow of 5.93 cfs and 2.87 cfs, respectively. However, the calculation of the background 7Q10 did not consider the historic flow from Coorson's Quarry. Since the historical flows from Coorson's Quarry were not available for the period of streamflow record used for calculation of the 7Q10, the quarry's contributions to the streamflow could not be distinguished from the natural baseflow. As a result, quarry discharge flows were added to the 7Q10 baseflow for the critical low-flow period. Although, sensitivity analysis showed that contributions from Coorson's Quarry did not impact the TMDL due to the

fact that critical stream segments associated with low DO were in upstream portions of the watershed. Once the low DO was remedied in those upstream portions through load reductions resulting from the TMDL, problems in the lower portions were improved regardless of the extra dilution provided by Coorson's Quarry.

The critical low-flow period was based on the best assumptions determined necessary to establish a TMDL that considered design flows from dischargers (with combined flows exceeding the 7Q10), quarry flows without a detailed record for comparison with streamflows for 7Q10 analysis, and model limitations. Any additional flow from seasonal considerations of 7Q10 conditions would require other special considerations regarding the contribution of quarry flows to this variation. It is possible that the additional 1.5 to 4.5 cfs resulting from recalculation of seasonal 7Q10 flows is the result of variations of quarry flows.

Moreover, with the flow budget based on the flow distribution observed in summer 2002, the majority of contributions to the Wissahickon baseflow during low-flow periods are in the bottom portions of the watershed that were insensitive to TMDL results (controlled by low dissolved oxygen in upstream stream segments). In other words, following distribution of the additional 1.5 to 4.5 cfs throughout the watershed, little additional flow is provided in the headwaters to impact TMDL results. Recall that headwater flow were raised slightly for the original critical flow period to prevent model instabilities resulting from too little flow. A slight raise in headwater background flows will unlikely be much greater than the values of these already-raised flows.

In conclusion, it is our judgement that recalculation of the 7Q10 flow based on seasonal considerations will have little impact on the TMDL. Without a full understanding of the contributions of the multiple contributors of flow during such refined periods (i.e., variation in quarry flows and STP dischargers), it is difficult to determine the flow budget without making gross assumptions. Therefore, given the amount of data available, the current estimation of the 7Q10 flow used in calculation of the TMDL is determined sufficient in ensuring the protection of Wissahickon Creek under critical low-flow conditions

VII. Use of a Seasonal Temperature Value

Comments received on the draft TMDLs showed a concern that seasonal temperature values were not used in establishing the TMDL. EPA used design temperatures of 20 degrees centigrade and 23 degrees centigrade for the trout stocking and warm water fishes use designation periods. EPA evaluated historical temperature data for the critical periods of each use designation (June and July for trout and August through September for warm water) and used the PADEP recommended 90 percentile temperature ("Implementation Guidance for Determining Water Quality Based Point Source Effluent Limitations", December 1985). This analysis resulted in seasonal stream temperatures for trout stocking period and warm water fishes period of 26.3 degrees centigrade and 24.5 degrees centigrade respectively. Allocations established for the trout stocking period using the temperature of 26.3 degrees are presented

below in Table D-12. As can be seen the allocations are slightly more stringent than the final allocations presented in the main body of this report. The allocations for the warm water fishes period using the seasonal temperature of 24.5 degrees shows the same decrease. These allocations are not presented here.

Table D-12: Allocations at Seasonal Temperatures - Trout Stocking

	North Wales	Upper Gwynedd	Ambler	Abington	Upper Dublin
DO (mg/L)	7.0	7.0	7.0	7.0	7.0
CBOD (mg/L)	2.0	3.0	9.7	4.5	9.75
NH3-N (mg/L)	0.38	0.56	1.5	0.62	2.0
NO2-NO3 (mg/L)	15.15	20.08	30.5	30.27	36.71
Orho-P (mg/L)	1.41	1.71	4.68	1.85	1.45

VIII. Summary of Seasonal Considerations

There was concern that EPA used very conservative assumptions by not taking various seasonal characteristics (a lower effluent flow, varying stream flow for different months, seasonal temperatures, etc) into consideration when the allocations were developed. As can be seen from above, more detailed analysis of the seasonal data that was available (with some assumptions for the effluent flows for several facilities) actually resulted in more stringent effluent limits. EPA however, is confident that the allocations, along with any margin of safety included in the modeling, presented in the final TMDL report are sufficient attain and maintain existing water quality standards of dissolved oxygen. However, it is recommended that future stream analysis be conducted following application of the final allocations to assure that standards are being met and that additional treatment, for the dissolved oxygen standards, is not required.